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FIG. 1

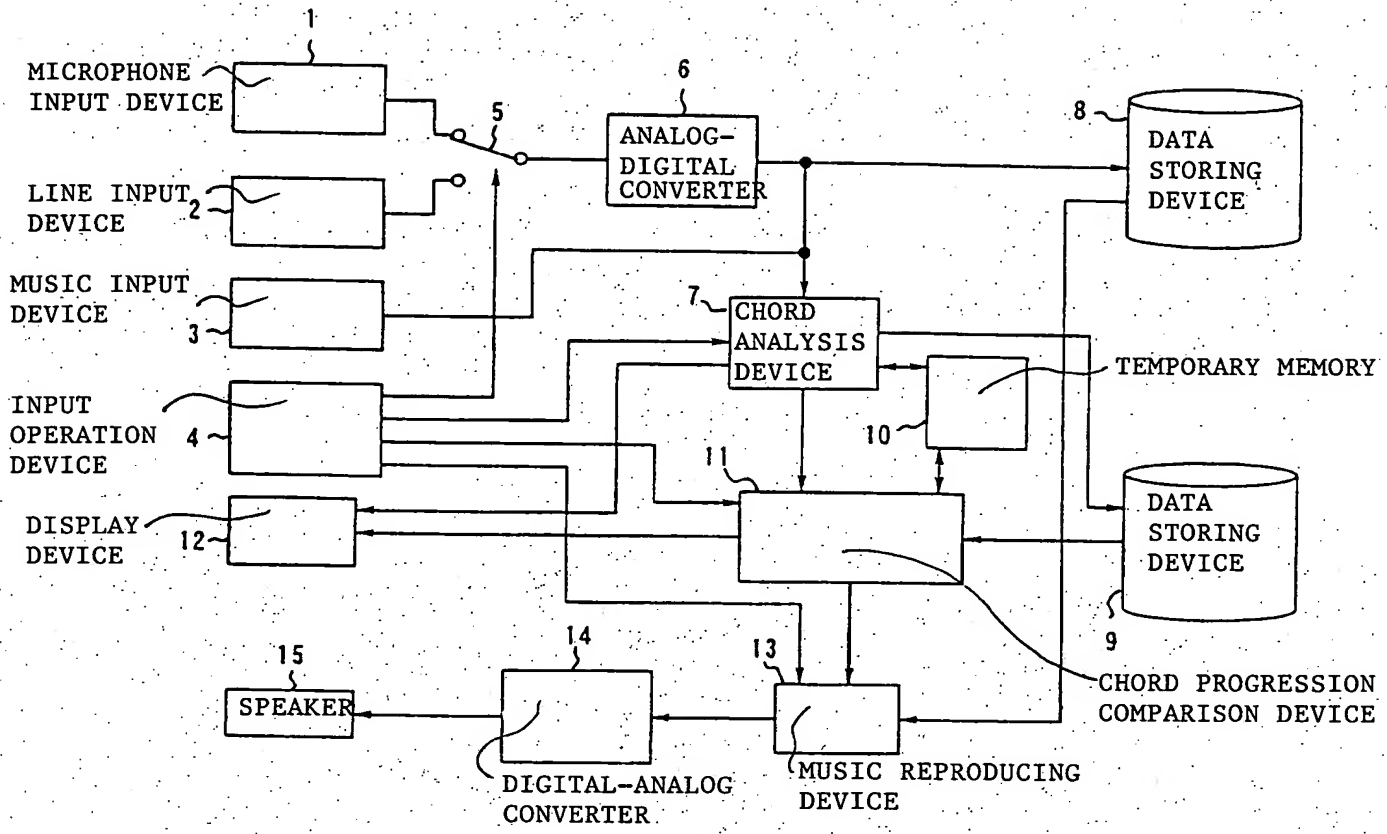
1
MICROPHONE INPUT DEVICE
6
5
ANALOG-DIGITAL CONVERTER
8
DATA STORING DEVICE
LINE INPUT DEVICE
2
MUSIC INPUT DEVICE
3
7
CHORD ANALYSIS DEVICE
TEMPORARY MEMORY
INPUT OPERATION DEVICE
4
10
11
DISPLAY DEVICE
12
DATA STORING DEVICE
9
15
14
13
SPEAKER
CHORD PROGRESSION COMPARISON DEVICE
DIGITAL-ANALOG CONVERTER
MUSIC REPRODUCING DEVICE

FIG. 2

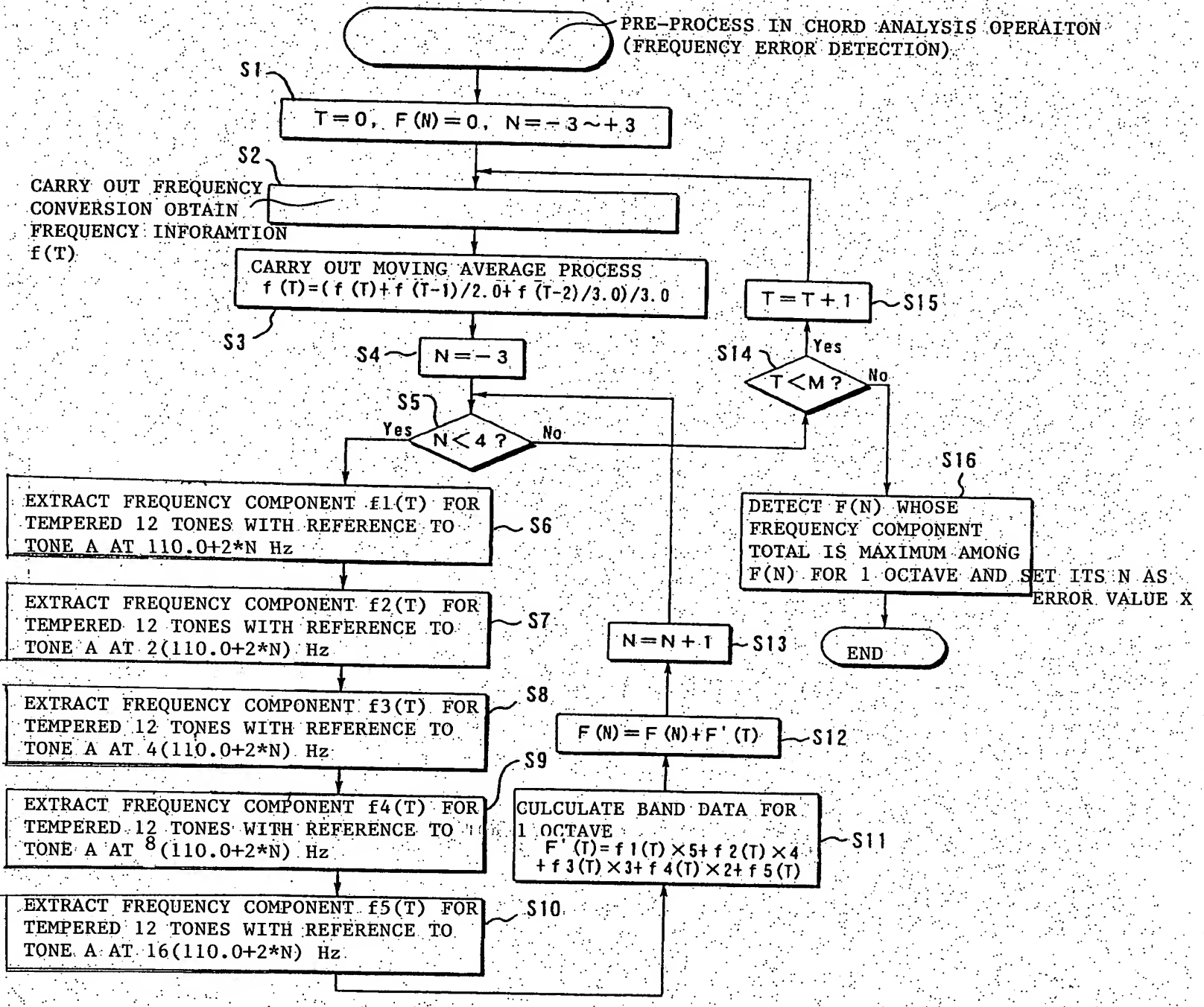
PRE-PROCESS IN CHORD ANALYSIS OPERAITON (FREQUENCY ERROR DETECTION)
S1
T=0, F(N)=0, N=-3~+3
S2
CARRY OUT FREQUENCY CONVERSION OBTAIN FREQUENCY INFORAMTION f(T)
CARRY OUT MOVING AVERAGE PROCESS f(T)=(f(T)+f(T-1)/2.0+f(T-2)/3.0)/3.0
S3
S4
N=-3
S5
Yes
N<4?
No
EXTRACT FREQUENCY COMPONENT f1(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 110.0+2*N Hz
S6
EXTRACT FREQUENCY COMPONENT f2(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 2(110.0+2*N) Hz
S7
EXTRACT FREQUENCY COMPONENT f3(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 4(110.0+2*N) Hz
S8
EXTRACT FREQUENCY COMPONENT f4(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 8(110.0+2*N) Hz
S9
EXTRACT FREQUENCY COMPONENT f5(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 16(110.0+2*N) Hz
S10
CULCULATE BAND DATA FOR 1 OCTAVE
F'(T)=f1(T)×5+f2(T)×4+f3(T)×3+f4(T)×2+f5(T)
S11
F(N)=F(N)+F'(T)
S12
N=N+1
S13
T<M?
S14
Yes
No
T=T+1
S15
S16
DETECT F(N) WHOSE FREQUENCY COMPONENT TOTAL IS MAXIMUM AMONG F(N) FOR 1 OCTAVE AND SET ITS N AS ERROR VALUE X
END

FIG. 3

A	1.0
A#	AX1.059163
B	AX1.124622
C	AX1.189207
C#	AX1.259921
D	AX1.334840
D#	AX1.414214
E	AX1.498307
F	AX1.587401
F#	AX1.681793
G	AX1.781797
G#	AX1.887749
A	AX2.0

FIG. 4

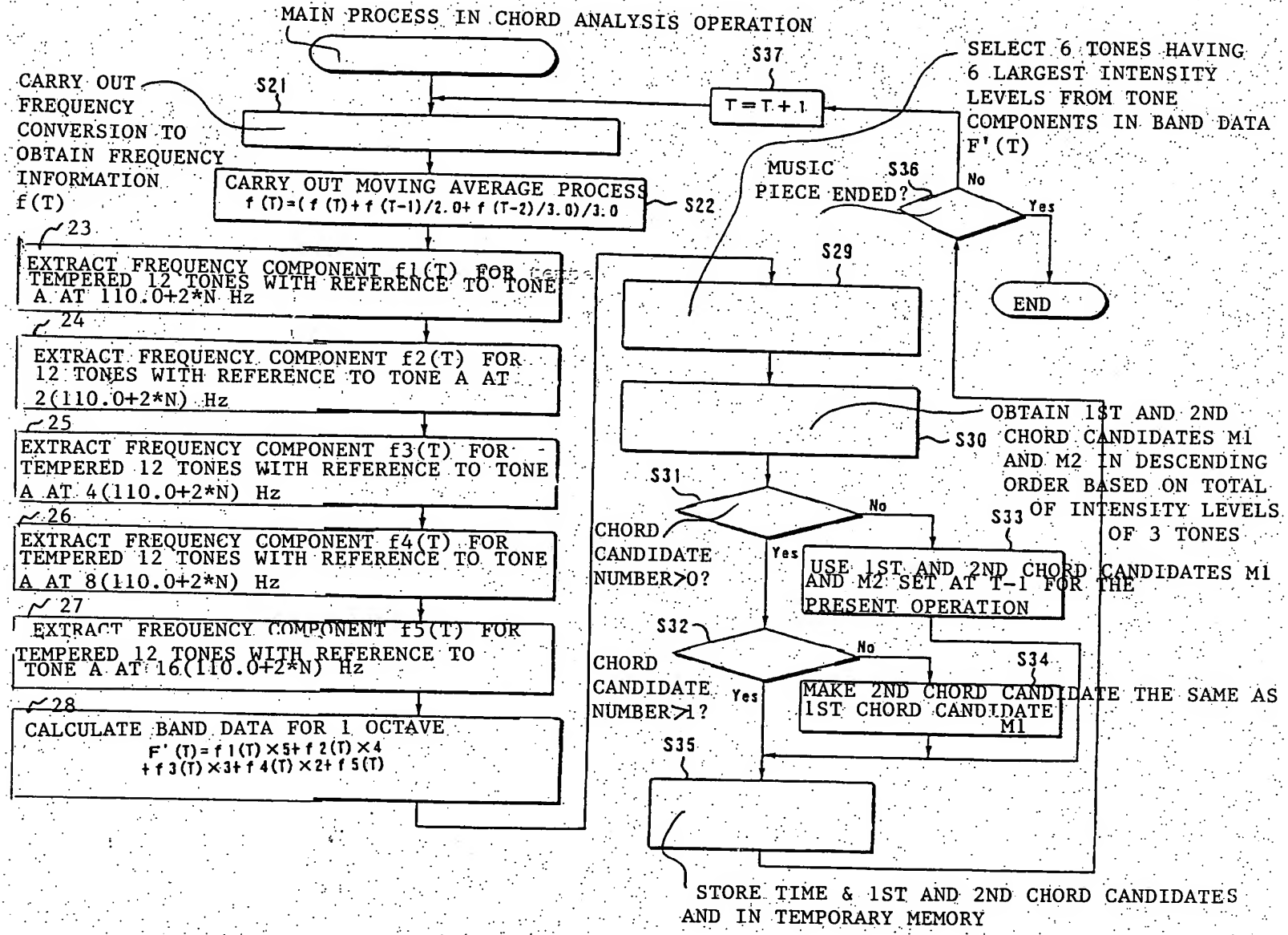
MAIN PROCESS IN CHORD ANALYSIS OPERATION
S21
CARRY OUT FREQUENCY CONVERSION TO OBTAIN FREQUENCY INFORMATION f(T)
CARRY OUT MOVING AVERAGE PROCESS
f(T)=(f(T)+f(T-1)/2.0+f(T-2)/3.0)/3.0
S22
23
EXTRACT FREQUENCY COMPONENT f1(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 110.0+2*N Hz
24
EXTRACT FREQUENCY COMPONENT f2(T) FOR 12 TONES WITH REFERENCE TO TONE A AT 2(110.0+2*N) Hz
25
EXTRACT FREQUENCY COMPONENT f3(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 4(110.0+2*N) Hz
26
EXTRACT FREQUENCY COMPONENT f4(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 8(110.0+2*N) Hz
27
EXTRACT FREQUENCY COMPONENT f5(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 16(110.0+2*N) Hz
28
CALCULATE BAND DATA FOR 1 OCTAVE
F'(T)=f1(T)×5+f2(T)×4+f3(T)×3+f4(T)×2+f5(T)
S29
SELECT 6 TONES HAVING 6 LARGEST INTENSITY LEVELS FROM TONE COMPONENTS IN BAND DATA F'(T)
S30
OBTAIN 1ST AND 2ND CHORD CANDIDATES M1 AND M2 IN DESCENDING ORDER BASED ON TOTAL OF INTENSITY LEVELS OF 3 TONES
S31
CHORD CANDIDATE NUMBER>0?
No
Yes
S33
USE 1ST AND 2ND CHORD CANDIDATES M1 AND M2 SET AT T-1 FOR THE PRESENT OPERATION
S32
CHORD CANDIDATE NUMBER>1?
No
Yes
S34
MAKE 2ND CHORD CANDIDATE THE SAME AS 1ST CHORD CANDIDATE M1
S35
STORE TIME & 1ST AND 2ND CHORD CANDIDATES AND IN TEMPORARY MEMORY
S36
MUSIC PIECE ENDED?
No
Yes
END
S37
T=T+1

FIG. 5

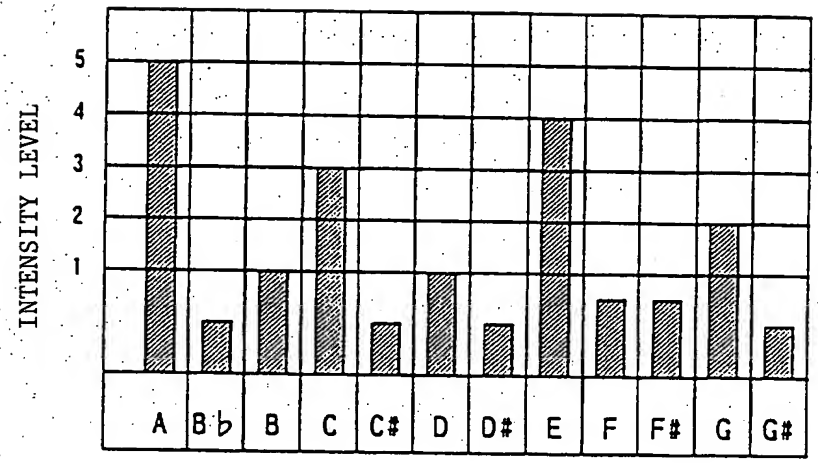
INTENSITY LEVEL
5
4
3
2
1
A
B♭
B
C
C#
D
D#
E
F
F#
G
G#

FIG. 6

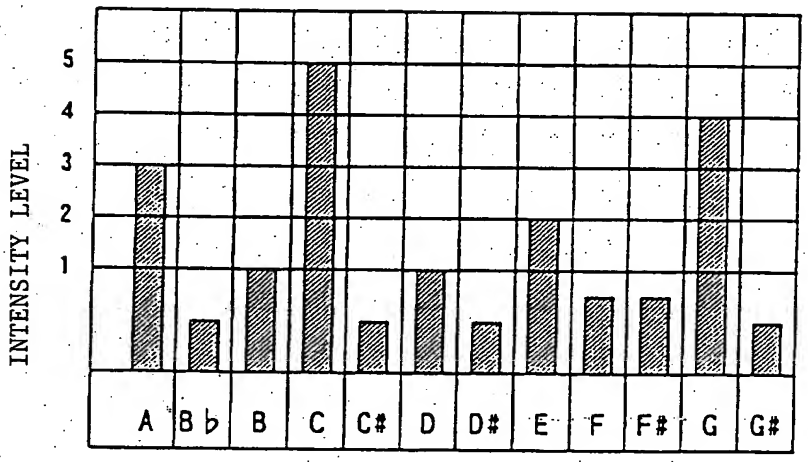
INTENSITY LEVEL
5
4
3
2
1
A
B♭
B
C
C#
D
D#
E
F
F#
G
G#

FIG. 7

A+C+E+G(Am7)
→ A+C+E(Am) | C+E+G(C)
A+C+E♭+F#(Adim7)
→ A+C+E♭(Adim7^{CANDIDATE})| C+E♭+F#(Cdim7^{CANDIDATE})
A+C#+E+G(A7)
→A+C#+E(A) | A+C#+G(A7^{CANDIDATE})| C#+E+G(C#dim7^{CANDIDATE})
A+C+E+G+B(Am7.9)
→A+C+E(Am) | C+E+G(C) | E+G+B(Em)

FIG. 8

TIME (4 BYTES) 1ST CHORD CANDIDATE (1BYTE) 2ND CHORD CANDIDATE (1 BYTE)
TIME (4 BYTES) 1ST CHORD CANDIDATE (1 BYTE) 2ND CHORD CANDIDATE (1 BYTE)
⋮
TIME (4 BYTE) 1ST CHORD CANDIDATE (1 BYTE) 2ND CHORD CANDIDATE (1 BYTE)

FIG. 9A

FUNDAMENTAL TONE	
A	0x00
A#	0x01
B	0x02
C	0x03
C#	0x04
D	0x05
D#	0x06
E	0x07
F	0x08
F#	0x09
G	0x0A
G#	0x0B

FIG. 9B

ATTRIBUTE	
MAJOR	0x00
MINOR	0x02
7TH CANDIDATE	0x01
DIM 7TH CANDIDATE	0x03

FIG. 9C

ATTRIBUTE (LOWER 4 BITS) +
FUNDAMENTAL TONE (LOWER 4 BITS)

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FIG. 10

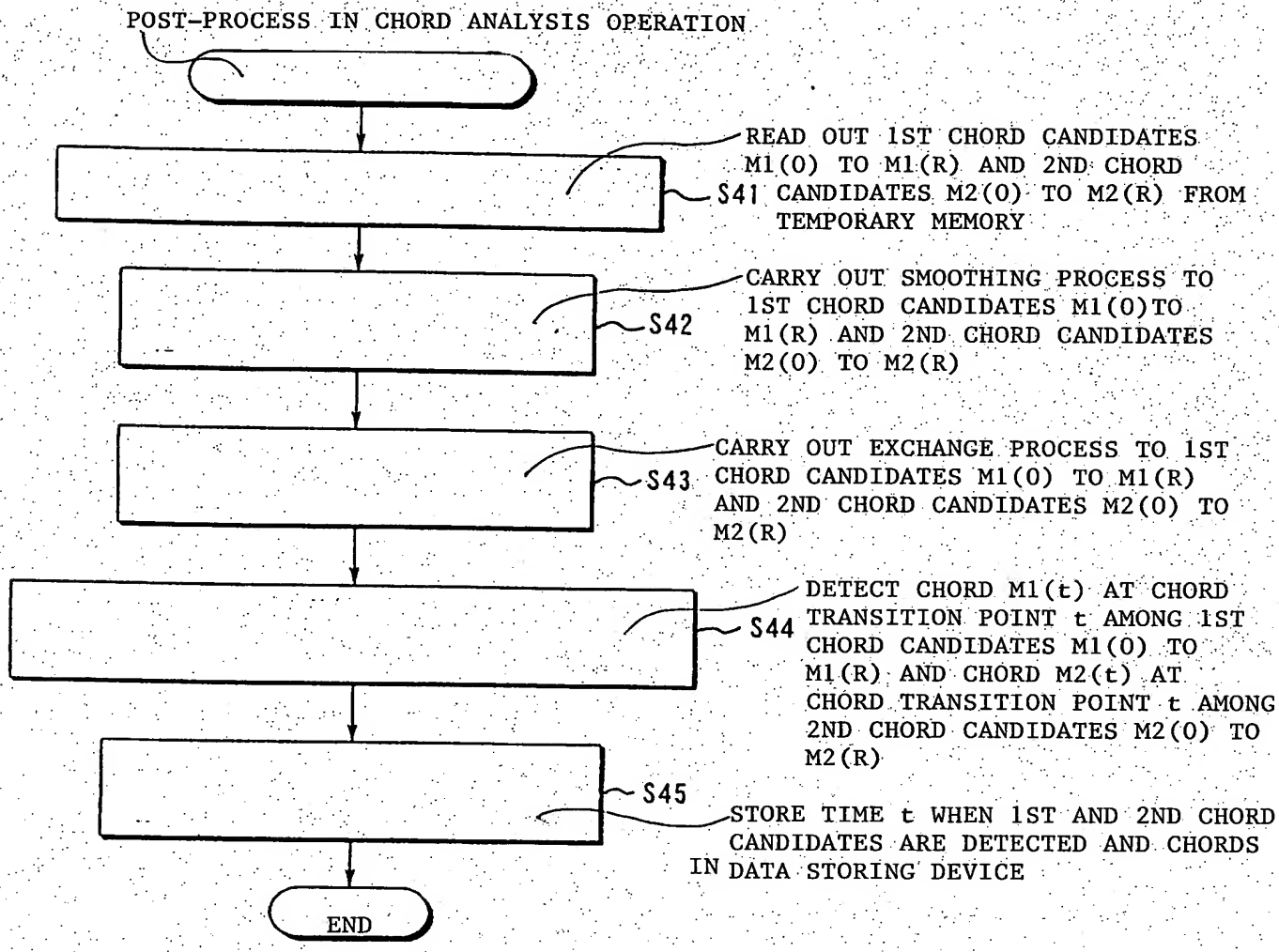

FIG. 11

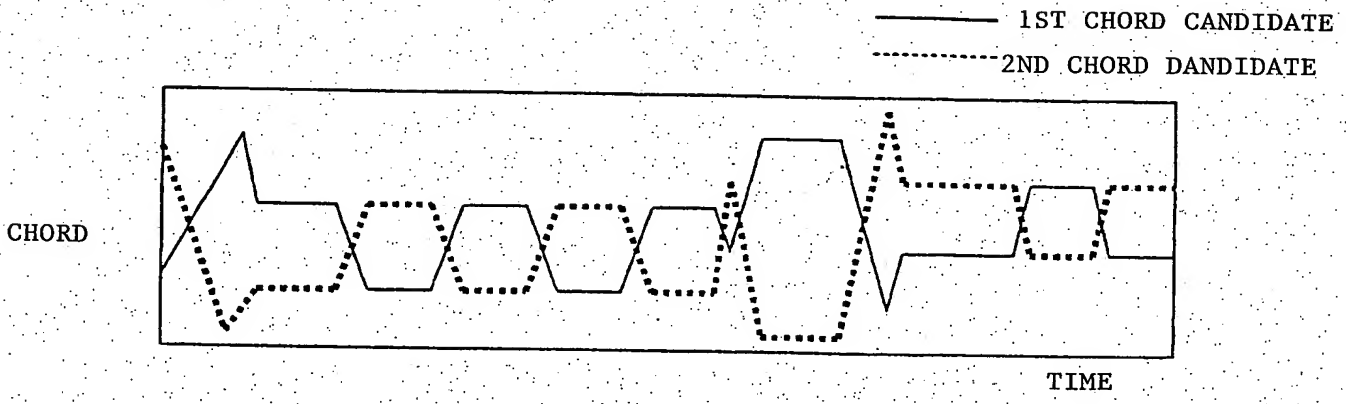

FIG. 12

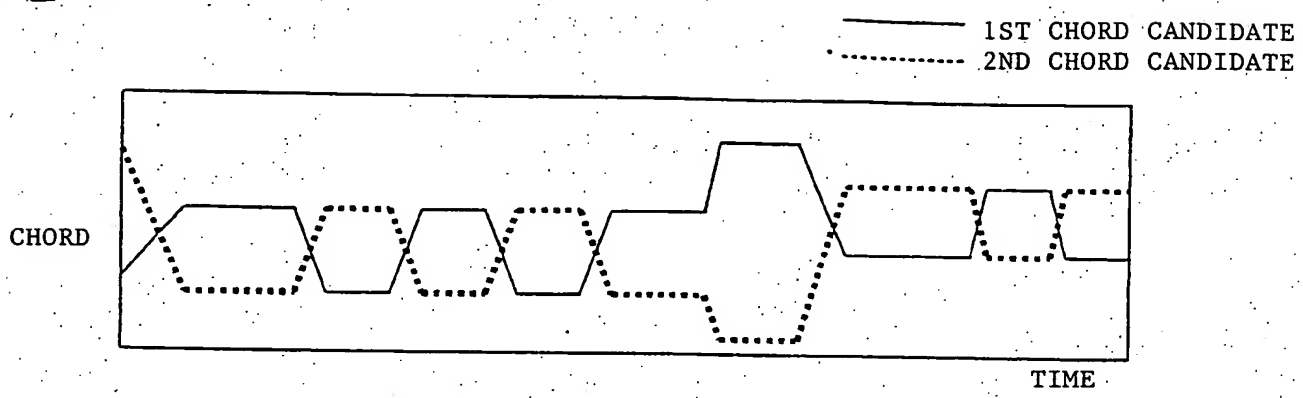
1ST CHORD CANDIDATE
2ND CHORD CANDIDATE
CHORD
TIME

FIG. 13

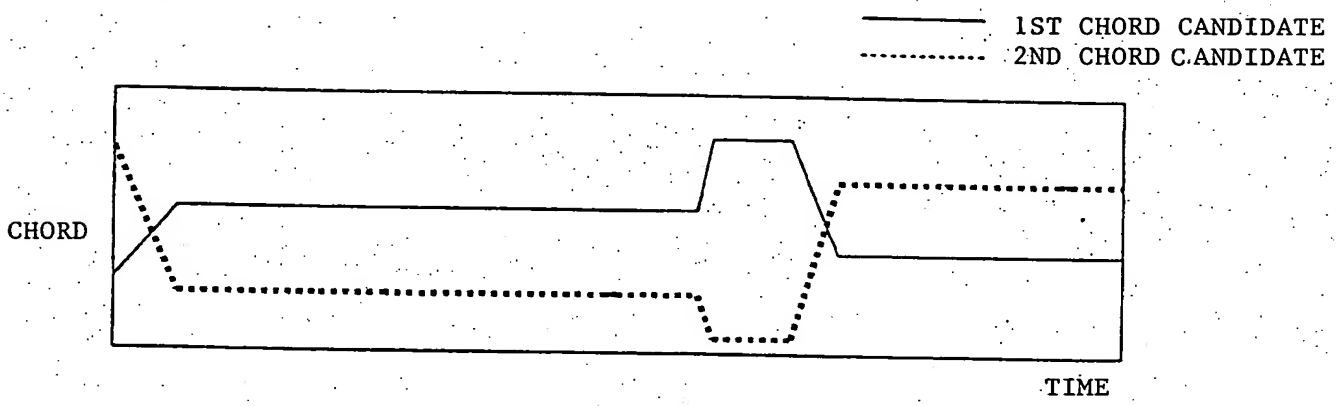
1ST CHORD CANDIDATE
2ND CHORD CANDIDATE
CHORD
TIME

FIG.14A

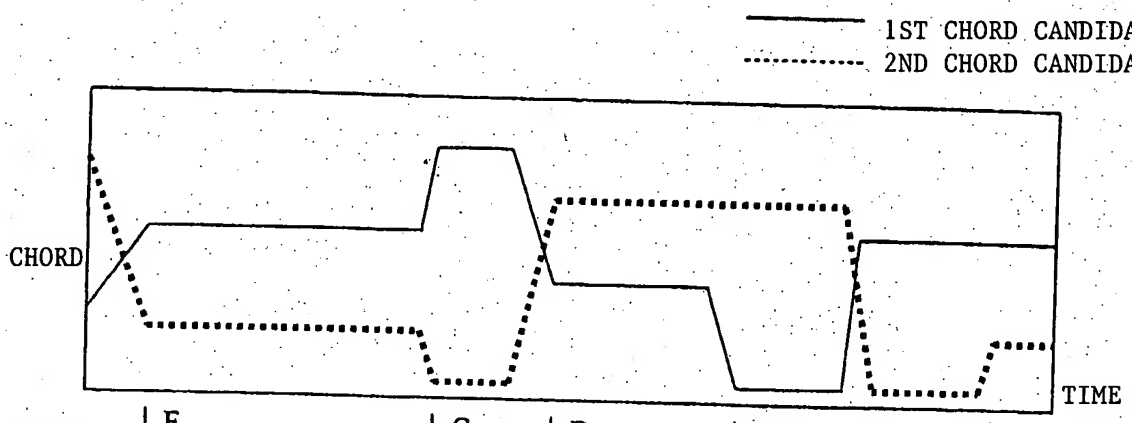

FIG. 14B

TRANSITION OF 1ST CHORD CANDIDATE	F 0x08 ←TIME (T1(0))	G 0x0A T1(1)	D 0x05) T1(2)	B♭ 0x01 T1(3)	F 0x08 T1(4)

FIG.14C

TRANSITION OF 2ND CHORD CANDIDATE	C 0x03 ←TIME (T2(0))	B♭ 0x01 T2(1)	F#m 0x29 T2(2)	B♭ 0x01 T2(3)	C 0x03 T2(4)

FIG. 14D

INDENTIFICATION INFORMATION FOR MUSIC PIECES(FILE NAMES, ETC.) (512 BYTES)

NUMBER OF 1ST CHORD CANDIDATES (4 BYTES) T1(0) (4 BYTES)[0x08] T1(1) (4 BYTES)[0x0A] T1(2) (4 BYTES)[0x05] T1(3) (4 BYTES)[0x01] T1(4) (4 BYTES)[0x08].....

NUMBER OF 2ND CHORD CANDIDATES(4BYTES) T2(0) (4BYTES)[0x03] T2(1) (4BYTES)[0x01] T2(2) (4BYTES)[0x29] T2(3) (4BYTES)[0x01] T2(4) (4 BYTES)[0x03].....

FIG. 15

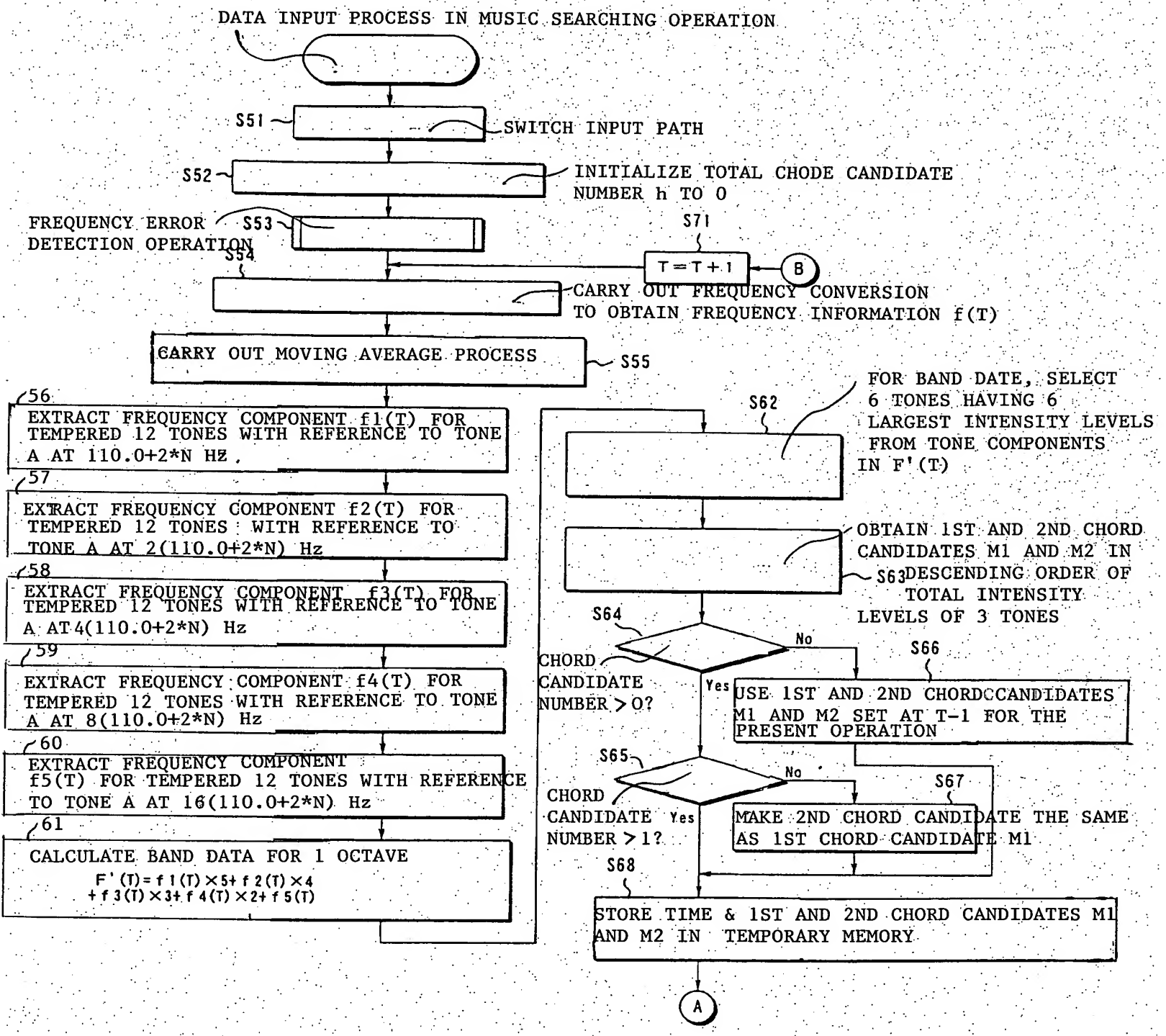
DATA INPUT PROCESS IN MUSIC SEARCHING OPERATION
S51
SWITCH INPUT PATH
S52
INITIALIZE TOTAL CHODE CANDIDATE NUMBER h TO 0
FREQUENCY ERROR DETECTION OPERATION
S53
S71
T=T+1
B
S54
CARRY OUT FREQUENCY CONVERSION TO OBTAIN FREQUENCY INFORMATION f(T)
CARRY OUT MOVING AVERAGE PROCESS
S55
56
EXTRACT FREQUENCY COMPONENT f1(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 110.0+2*N HZ.
57
EXTRACT FREQUENCY COMPONENT f2(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 2(110.0+2*N) Hz
58
EXTRACT FREQUENCY COMPONENT f3(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 4(110.0+2*N) Hz
59
EXTRACT FREQUENCY COMPONENT f4(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 8(110.0+2*N) Hz
60
EXTRACT FREQUENCY COMPONENT f5(T) FOR TEMPERED 12 TONES WITH REFERENCE TO TONE A AT 16(110.0+2*N) Hz
61
CALCULATE BAND DATA FOR 1 OCTAVE
F'(T)=f1(T)×5+f2(T)×4 +f3(T)×3+f4(T)×2+f5(T)
S62
FOR BAND DATE, SELECT 6 TONES HAVING 6 LARGEST INTENSITY LEVELS FROM TONE COMPONENTS IN F'(T)
OBTAIN 1ST AND 2ND CHORD CANDIDATES M1 AND M2 IN DESCENDING ORDER OF TOTAL INTENSITY LEVELS OF 3 TONES
S63
S64
CHORD CANDIDATE NUMBER > 0?
No
Yes
S66
USE 1ST AND 2ND CHORDCCANDIDATES M1 AND M2 SET AT T-1 FOR THE PRESENT OPERATION
S65
CHORD CANDIDATE NUMBER > 1?
No
Yes
S67
MAKE 2ND CHORD CANDIDATE THE SAME AS 1ST CHORD CANDIDATE M1
S68
STORE TIME & 1ST AND 2ND CHORD CANDIDATES M1 AND M2 IN TEMPORARY MEMORY
A

FIG. 16

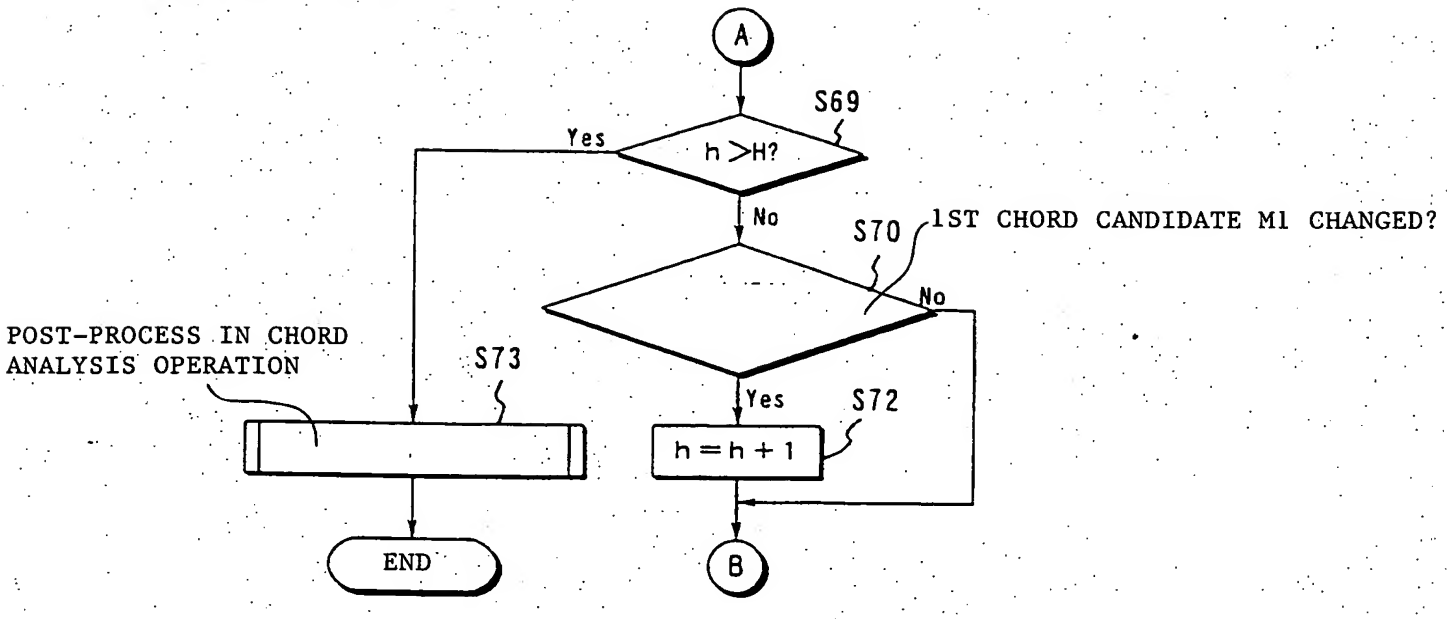
A
S69
h > H?
Yes
No
S70
1ST CHORD CANDIDATE M1 CHANGED?
No
Yes
S72
h = h + 1
POST-PROCESS IN CHORD ANALYSIS OPERATION
S73
END
B

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FIG. 17

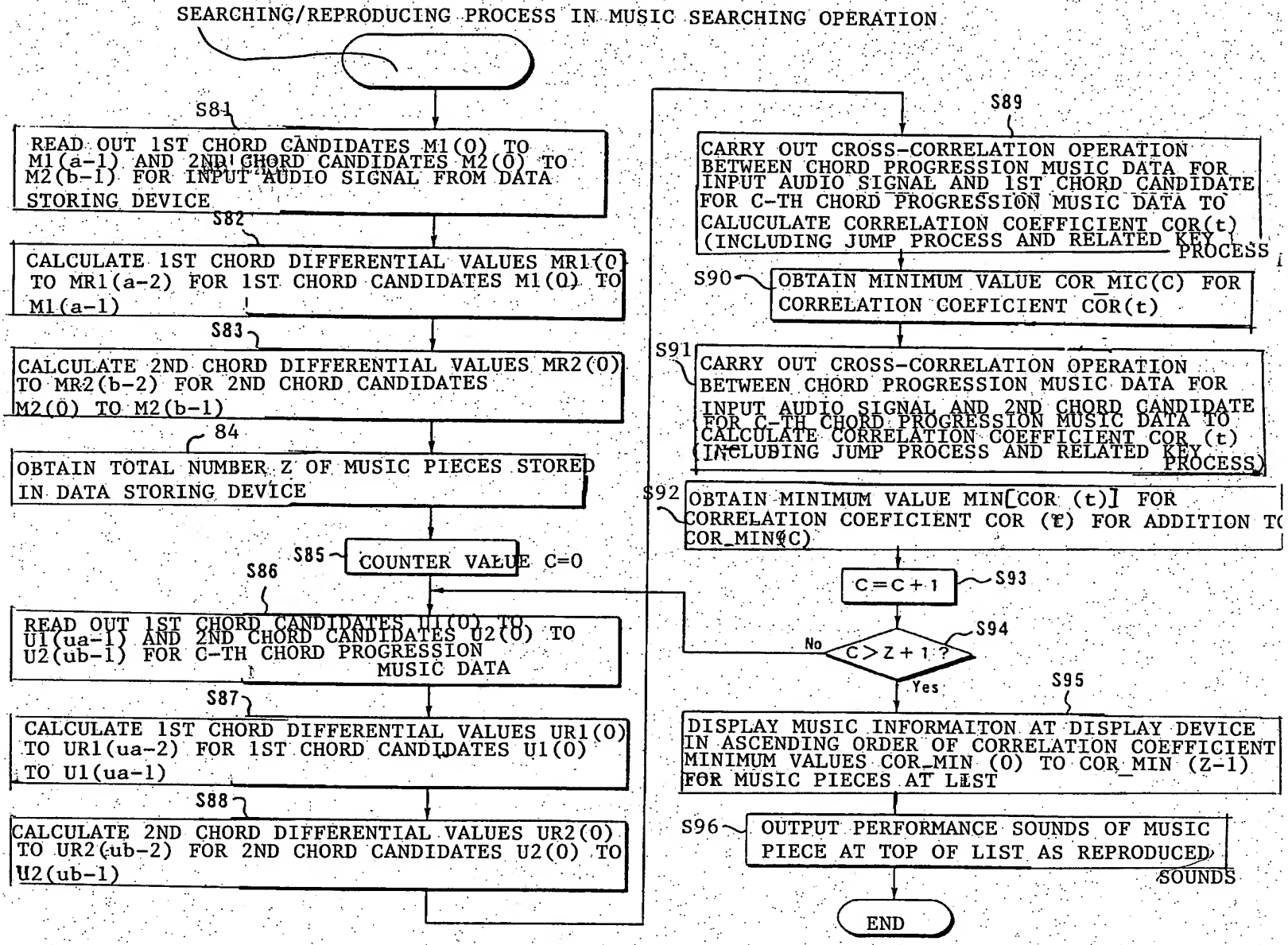


FIG. 18

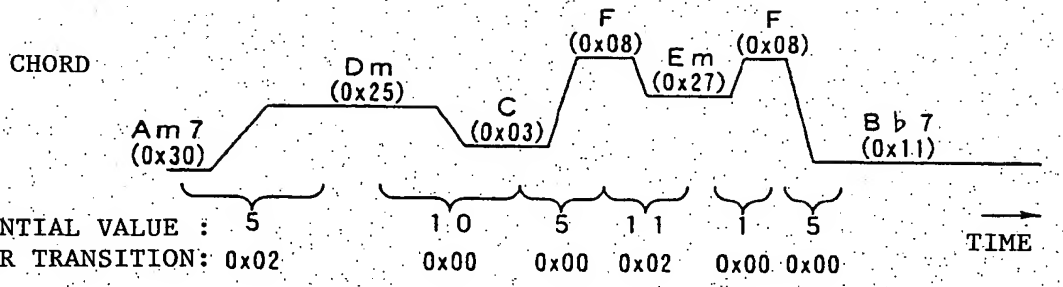


FIG. 19A

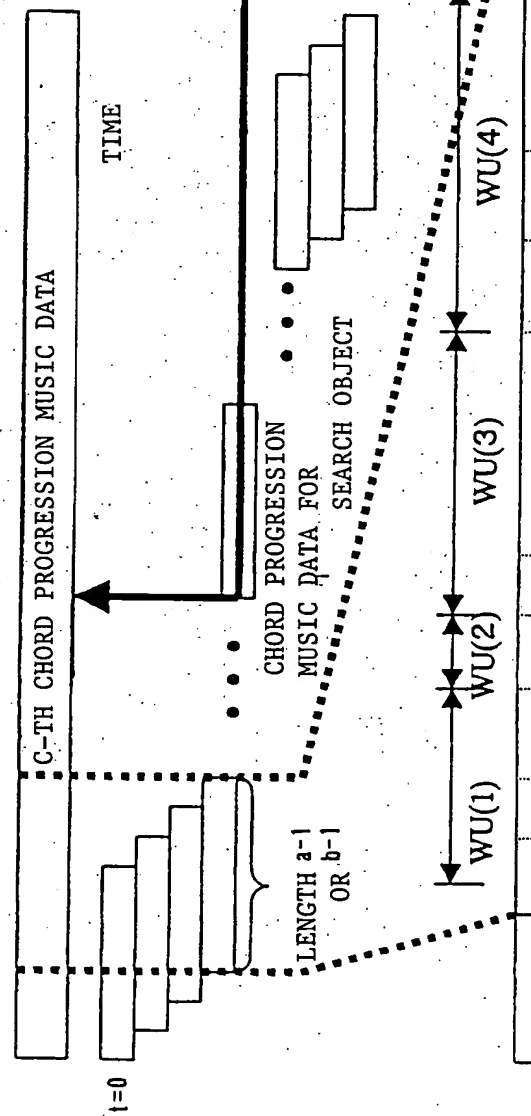


FIG. 19B

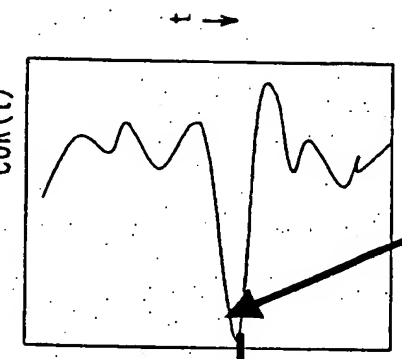


FIG. 19C

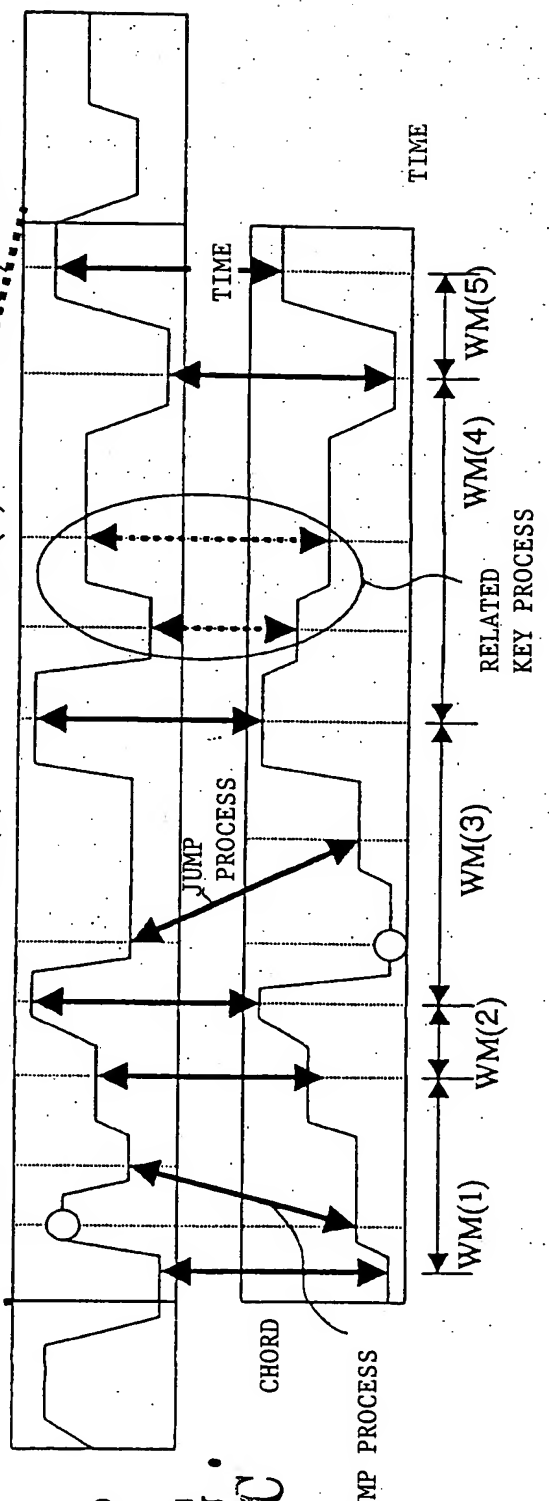
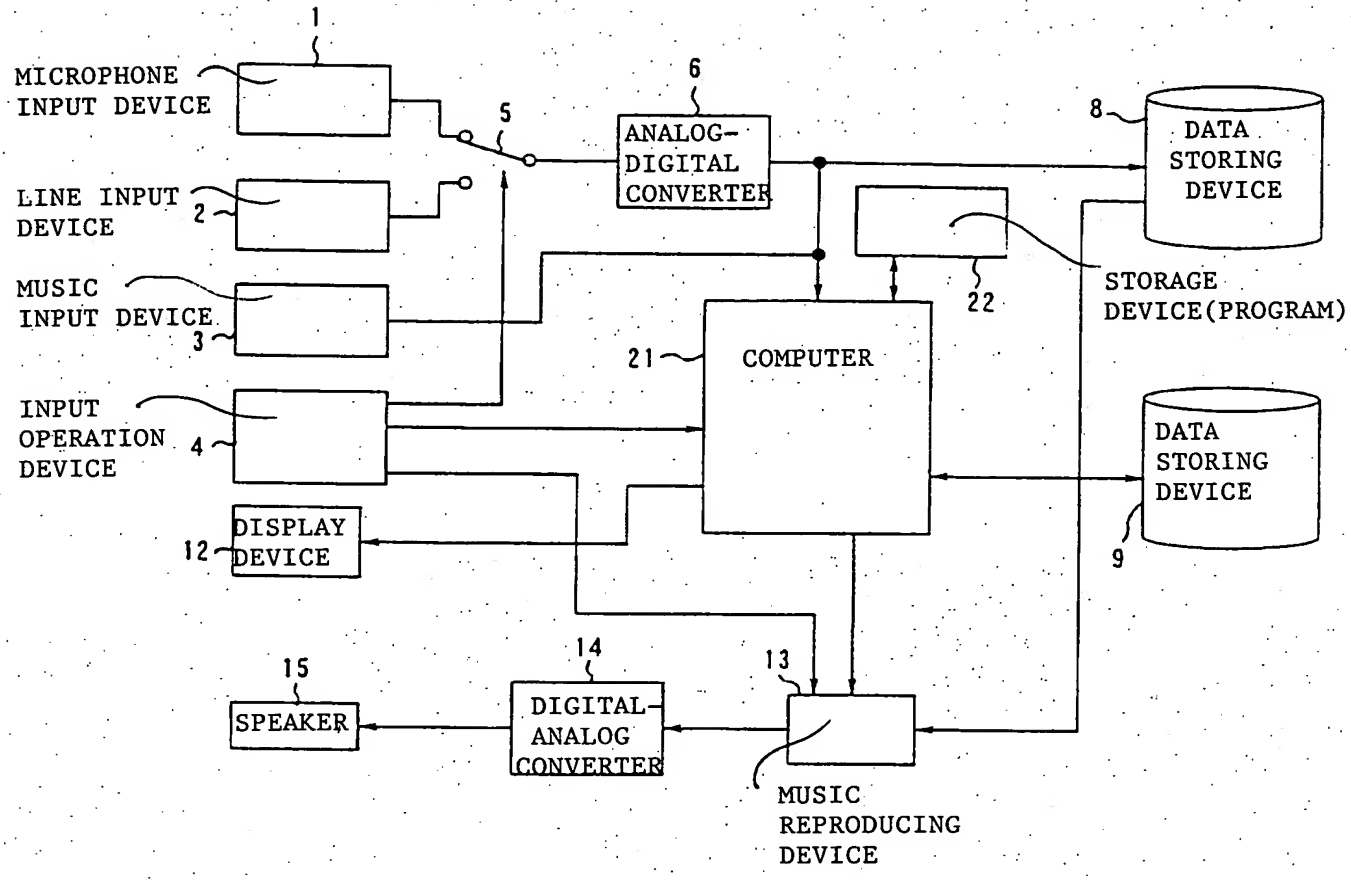


FIG. 20


1
MICROPHONE INPUT DEVICE
5
6
ANALOG-DIGITAL CONVERTER
8
DATA STORING DEVICE
LINE INPUT DEVICE
2
MUSIC INPUT DEVICE
3
22
STORAGE DEVICE(PROGRAM)
21
COMPUTER
INPUT OPERATION DEVICE
4
DATA STORING DEVICE
9
DISPLAY DEVICE
12
15
SPEAKER
14
DIGITAL-ANALOG CONVERTER
13
MUSIC REPRODUCING DEVICE